# Problem Statement and Goals
# RoCam

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Table 1: Revision History

| **Date** | **Developer(s)** | **Change** |
|---|---|---|
| Sept. 8, 2025 | Jianqing Liu | Initial Draft |
| Sept. 9, 2025 | Zifan Si | Details Elaboration |
| Sept. 10, 2025 | Zifan Si | Fix based on teammate suggestion |
| Sept. 10, 2025 | Jianqing Liu | Refine inputs, outputs, and goals |
| Sept. 12, 2025 | Jianqing Liu | Update Depolyment Environment |

## 1 Problem Statement

### 1.1 Problem

In model rocketry, two of the hardest engineering problems are staging failures and parachute tangling. These problems are hard to study because they happen in mid-flight, where direct observation is limited. Without reliable tracking, engineers cannot fully understand these failures or design better solutions. As a result, recurring issues remain unresolved, slowing progress in both safety and performance of future rockets.

Model rockets travel at very high speeds, sometimes faster than Mach 3 and over 100 km in altitude (TODO: citation). Under these conditions, manual camera tracking is not possible.

Tracking a small model rocket is even harder than tracking large rockets suchas the Falcon 9. Smaller size and uncontrolled launch conditions make accurate detection and continuous tracking much more difficult.

Some commercial tracking systems exist (TODO: citation), but they do not have the accuracy or speed needed to follow small, fast-moving rockets. This gap shows the need for a dedicated system that can provide clear, real-time observation of rocket flights.

## 1.2 Inputs and Outputs

- **Inputs**
  - Realtime camera feed
  - State information from gimbal
  - Manual camera gimbal adjustment commands from user
- **Outputs**
  - Camera gimbal adjustment commands to maintain visual lock of the rocket
  - Realtime video preview via ethernet
  - Realtime stabilized video output via HDMI with the rocket centered in frame
  - Recorded video with the rocket centered in frame

## 1.3 Performance Objectives

- System should be able to handle 1080p 60fps camera feed
- System should be able to output 1080p 60fps video via HDMI
- Realtime video preview should be at least 15fps

## 1.4 Stakeholders

### Direct Stakeholders

1. **McMaster Rocketry Team**: The primary end users who will deploy the system during launches. They depend on accurate real-time tracking to analyze staging, parachute deployment, and overall flight performance.
2. **Dr. Shahin Sirouspour (Supervisor)**: Provides technical guidance, project oversight, and mentorship. Ensures the project aligns with academic standards, engineering best practices, and capstone deliverable expectations.

### Indirect Stakeholders

1. **Aerospace Engineers and Researchers**: Benefit from high-quality flight footage to validate models, improve rocket designs, and support experimental research.
2. **Event Organizers and Safety Officers**: Rely on reliable tracking for live monitoring of rocket flights, particularly for confirming parachute deployment and safe recovery during launch events.
3. **Engineering and Robotics Community**: May adapt the system's design principles for other domains requiring precise tracking of fast-moving objects, such as UAV navigation, sports analytics, or autonomous robotics.
4. **Potential Commercial and Industrial Users**: Could adopt the system for broader applications in surveillance, wildlife monitoring, or industrial inspections where real-time vision-guided tracking is valuable.

### 1.5 Environment

There are four pieces of the hardware related to this project:

1. A gimbal with a camera mounted on it
2. An STM32 microcontroller
3. An Nvidia Jetson prosessing module
4. A user laptop running a browser connected to the Jetson

Three pieces of software will be developed as a part of this project:

1. Baremetal code that runs on the STM32 microcontroller
2. Code that runs on the Jetson, which expects an linux environment with JetPack 6
3. Code that runs on the user browser, which expects any recent versions of major browsers

## 2 Goals

The goal of the project is to track small-scale model rocket launches with apogee <200m, while achieving all the performance objectives listed in Section 1.3.

## 3 Stretch Goals

- Handle 4K 60fps camera stream.
- Include functionalities to control the zoom and the focus of more advanced cameras.
- Integration with a full-size gimbal developed by the McMaster Rocketry Team.
- Track high-powered model rocket launches (apogee 3km+), while achieving all the performance objectives listed in Section 1.3.

## 4 Extras

### 4.1 Circuit Design

As this project require to use of a mechanical gimbal, electrical circuit is needed to interface between the host computer and the actuators. A seperate document will be authored to detail the circuit design.

### 4.2 User Instructional Video

An user instructional video will be created to help potential users to understand how to use the system.

## Appendix — Reflection

The purpose of reflection questions is to give you a chance to assess your own learning and that of your group as a whole, and to find ways to improve in the future. Reflection is an important part of the learning process. Reflection is also an essential component of a successful software development process.

Reflections are most interesting and useful when they're honest, even if the stories they tell are imperfect. You will be marked based on your depth of thought and analysis, and not based on the content of the reflections themselves. Thus, for full marks we encourage you to answer openly and honestly and to avoid simply writing "what you think the evaluator wants to hear."

Please answer the following questions. Some questions can be answered on the team level, but where appropriate, each team member should write their own response:

1. What went well while writing this deliverable?
2. What pain points did you experience during this deliverable, and how did you resolve them?
3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?